Review Article

Developments on the tubers: *Colocasia esculenta (*L) Schott (Taro) and *Xanthosoma sagittifolium* (L) Schott (Tannia)

Abstract

Two varieties of Cocoyam *Colocasia esculenta* (L) Schott (Taro) and *Xanthosoma sagittifolium* (L) Schott (Tannia) are experiencing renewed interest not only in Africa but also in the rest of the world. They are considered to be cheaper sources of carbohydrates than cereals or other bulbous crops because of their high calorie yield per hectare, low production costs, and relatively low susceptibility to insect and pest infestation. In addition to their nutritional benefits, they contain bioactive compounds such as polyphenols, proteins, mucilage, polysaccharides, lipids and anti-polyphenol antioxidants. These bioactive compounds have been shown to provide consumers with health benefits such as anti-cancer, anti-inflammatory, antioxidant and dyslipemic properties. Interestingly, you don't need to consume the raw tubers or leaves to get these numerous health benefits, as the different parts of the plants which are nutrient-dense, have been used in various food applications such as flour, chips, poi, syrup, weaning foods for babies, local delicacies, and starch production. These products compete favourably with products from other root and tuber crops. Therefore, this article describes various value-added products made from Cocoyam that can be consumed to reap the numerous health benefits associated with consuming Cocoyam.

Introduction

Cocoyam

Cocoyam, a monocot, is an edible aroid in the Araceae family. There are two main varieties in Nigeria: *Colocasia esculenta* (L) Taro, Schott and *Xanthosoma sagittifolium* (L) Schott, Tannia. It is recognized as cheaper carbohydrate sources than grains or other tuber crops (Iwe, 2002). It has high caloric yield per hectare, low production cost (Aderanju *et al.,* 2019) and has relatively low susceptibility to insect and pest attack (Iwuagwu *et al*., 2017). It has the potential of meeting the fundamental requirement of the body being very rich in nutrients notably carbohydrates, proteins, vitamins and minerals (Iwe, 2002). Due to its high nutrient content, cocoyam is consumed by the rich and poor. The corms of tannia cocoyam are highly superior to taro cocoyam in energy and protein although they contain much less calcium, magnesium, zinc, and trypsin inhibitor than taro cocoyam (Ubalua, 2016). Fresh corms of tannia contains 20-30% starch and 1-4% proteins. Nearly all calcium present is in the form of calcium oxalate (Bradbury and Holloway, 1988).

Nutritional composition of cocoyam

Cocoyam, like other roots and tubers, contains dietary energy which is mainly carbohydrate. It has more carbohydrate than potatoes (Lewu *et al.*, 2010), about 100 g provides 112 calories. It has low protein content 1-2%, like other root crop proteins, which means that sulphur-containing amino acids are relatively small (Iwe, 2002). However, it contains very low fat and protein than in cereals and pulses (Iwe 2002). The levels of protein are almost the same as that of yam, cassava, potato, and banana (Lewu, *et al.*, 2010). Despite their high starch content, cocoyam has a higher content of protein and amino acids than many other roots and tuber (Sefa-Dede and Sackey, 2002). Table 1 shows the nutritional content of cocoyam. The protein content of cocoyam is higher (1.12% for taro and 1.55% for tannia) than that of other root crops (Owusu-Darko, 2014).

Cocoyam, contains high-quality Phyto-nutrition profile comprising of dietary fibre, and antioxidants with a moderate quantity of minerals, and vitamins, as well as being gluten-free (Sanful and Darko, 2010). Valuable B-complex group of vitamins is also present in cocoyam which includes; pyridoxine (vitamin B6), folate, riboflavin, pantothenic acid, and thiamine. Also, the corms contain some important minerals like zinc, magnesium, copper, iron, and manganese. Researchers like de Castro *et al*. (1992) and Monte Neschich *et al*. (1995) studied two major globulins from corms of taro and they observed the existence of two unrelated globulin families during root development; a G2 and G1 protein- which accounts for the total soluble tuber proteins (about 80%).

Cocoyam is a good source of thiamine, riboflavin, phosphorus, and zinc, as well as a source of vitamin B6, vitamin C, and niacin. It contains valuable vitamin B complex groups such as pyridoxine, folate, riboflavin, pantothenic acid and thiamine (Ramat, 2014). Due to its high water content, cocoyam is susceptible to microbial attack and spoilage, which contributes to the short shelf life of the tuber. The leaves are used to feed pigs because of their nutritional value (Agrid, 2006). The leaves are good sources of vitamins A and C and contain a fairer amount of protein than the tubers (Wada, *et al.,* 2019). Cocoyam's high vitamin B6 content is good for controlling high blood pressure and protecting the heart (Igwe *et al.,* 2004). Cocoyam contains some fiber that helps regulate gut health, lower cholesterol, and control blood sugar levels (Tie *et al.*, 2017). About 100 g of cocoyam pulp provides 4.1 g or 11% of the recommended daily fiber. The presence of slowly digesting complex carbohydrates leads to a gradual rise in blood sugar levels (Tie et al., 2017).

Cocoyam leaves also contain some phenolic flavonoid pigment antioxidants such as carotene along with vitamin A that help keep mucous membranes and eyesight healthy (Ojimelukwe *et al*., 2014). Minerals like zinc, magnesium, copper, iron and calcium are supplied by the tubers. The fat and sodium content of this plant is low and when consumed can help prevent hardening of the arteries, which is attributed to the consumption of foods high in cholesterol (Ramat, 2014). Drying can be used to dry aroids into flour for fufu, which is often eaten with soup in Nigeria. In the south-eastern regions of Nigeria, some amounts of tannia are used as a soup thickener when cooked and pounded to make a consistent paste (Adeyanju *et al.*, 2019). Young taro leaves are eaten as a vegetable in the South Pacific, also with coconut cream to make a dish called *luau,* and can be eaten with boiled or toasted taro, breadfruit, and banana.

Table 1: Nutritional content of the major edible aroids per 100g edible portion

Constituent	Taro *Colocasia esculenta*			Tannia (*Xanthosoma sagittifolium*)		
Major nutrients	Corms	Leaf	Stalk	Corms	Leaves	Shoots
Calories	102	94	24	133	34	33
Protein (g)	1.8	202	0.5	2.0	2.5	3.1
Fat (g)	0.1	0.4	0.2	0.3	1.6	0.6
Carbohydrate (g)	23	21	6	31	5	5
Fibre (g)	1.0	0.8	0.9	1.0	2.1	3.2
Calcium (mg)	51	34	49	20	95	49
Phosphorus (mg)	88	62	25	47	388	80
Iron (mg)	1.2	1.2	0.9	1.0	2.0	0.3
Vitamins						
β-carotene equiv. (μg)	Trace	Trace	180	Trace	3300	
Thiamine (mg)	0.10	0.12	0.02	0.10	-	-
Riboflavin (mg)	0.03	0.04	0.04	0.03	-	-
Niacin (mg)	0.8	1.0	0.4	0.5	-	-
Ascorbic acid (mg)	8.0	8.0	13	10	37	82

Source: Opara (2000)

Cocoyam's starch

The starch content of Cocoyam was given as 70-80% in the dry weight of tubers (Ahmed and Khan, 2013). Cocoyam starch is considered to be easily digestible and is therefore often used in baby foods in Hawaii and other Pacific islands, as well as in the diet of gluten-allergic and lactose-intolerant children (Ahmed and Khan, 2013). Cocoyam's starch is also good for those with stomach ulcers, those with pancreatic disease, chronic liver problems, and inflammatory bowel disease, and gallbladder disease (Lebot *et al*., 2011).

The size of the starch grains varies depending on the variety and ranges from 1.5 to 6.6 m. The shape of the grains is polygonal. Cocoyam starch contains about 50% less amylose than amylopectin. The cocoyam starch forms a clear and soft paste similar to potato starch. The gelatinization temperature of the starch depends on the variety and ripeness at the time of harvest and is lower with increasing age and ranges from 63-73 ° C (Lebot *et al.*, 2014; Ahmed and Khan, 2013). Cocoyam is grown for its starch, which can be baked, cooked, or made into snacks (chips or fries) to suit the growing city markets (Aderanju *et al* 2019).

Cocoyam's protein

Cocoyam contains approximately 11% protein, based on the dry weight of the tubers (Temesgen and Retta, 2015). This is more than the protein content of yam, cassava or sweet potato (Lewu *et al.,* 2010). Cocoyam's protein is rich in essential amino acids such as: threonine, leucine, arginine, valine and phenylalanine, and they are relatively more common in leaves than in tubers (Iwe, 2002). The protein content of the tuber is higher at the circumference of the tuber than in the middle. This suggests that the tubers should be peeled very thinly or cooked with their peels, otherwise a significant amount of protein may be lost during peeling.

Interestingly, cocoyam leaves have been reported to be richer in protein than the tubers. Due to the presence of symbiotic soil bacteria in its root and rhizome parts, cocoyam contains more protein than other root crops (FAO; 2008). The abundance of these symbiotic bacteria in soils helps cocoyam plants to grow in a variety of environment and environmental conditions (Lucy *et al.,* 2004).

Cocoyam's lipids

Cocoyam has a very low fat content and consists mainly of cell membrane lipids, which vary greatly between the different varieties. Overall, the fat content of cocoyam tubers is 0.3-0.6% (FAO, 1999; Lucy et al., 2004).

Cocoyam's Crude fiber

Cocoyam contains fiber. In studies on six varieties in Cameroon and Chad it was found that the crude fiber content in taro fluctuated between 0.3-3.8% (FAO, 2004). Cocoyam grown in American Samoa had an even wider range of total, soluble and insoluble fiber (5.02-9.01%) (Nip *et al.,* 1989; Nip, 1997; Njintang, 2008). Crude fibers are important because they facilitate nutrition, support the micro-supply of components and glucose metabolism, as well as slow down the process of absorption of undesirable food components such as cholesterol, shorten the intestinal passage, the concentration of total and LDL cholesterol (low density lipoprotein) in the blood , lowers postprandial glucose and insulin levels in the blood, acts as a buffer and reduces excessive acid secretion in the stomach, prevents constipation, increases water absorption of food, can increase food intake stability by changing the structure and density of food, texture, the form of a gel in food and the ability to thicken food (Njintang, 2008; Biziuk and Kuczynska, 2006).

Cocoyam's Minerals

Cocoyam contains quite a bit of ash. The ash content of Cocoyam ranges from 3.54-7.78% (Wada *et al.,* 2019). Essential minerals play an important role in metabolism and in physio-chemical processes such as maintaining pH and osmotic pressure, muscle contractions and gas transport. These minerals are important components of enzymes and hormones that are crucial for bone formation and vitamin synthesis (Lewu *et al.,* 2010; Temesgen and Ratta, 2010).

In addition, cocoyam has been reported to be an excellent source of minerals, including potassium 2271-4276.06 mg / 100 g), sodium (82-1521.34 mg / 100 g), magnesium (118-415.07 mg / 100 g), calcium (31-132 mg / 100 g), phosphorus (72.21-340 mg / 100 g) , Iron (8.6-610.8 mg / 100 g), zinc (2.63 mg / 100 g) and copper (1.04 mg / 100 g) (Temesgen and Ratta, 2010; Mergedus and Kristl, 2015). A high potassium to sodium ratio is recommended for high blood pressure.

The distribution of the various minerals in the tuber varies depending on the element. Minerals like P, Mg, Zn, Fe, Mn, Cu and Cd are mainly found in the upper part of the tuber, K, P, Mg, Zn, Fe, Cu and Cd are concentrated in the central part, and Ca is concentrated in the lower part and marginal parts of cocoyam tubers (Mergedus *et al*., 2015). The central part is always the most important from a nutritional point of view, but in order to increase the tuber yield it is necessary to reduce the amount of waste to remove the edge part.

Bioactive compounds in Cocoyam

The bioactive compounds contained in taro are mainly tarin, polyphenols, proteins, mucilage, polysaccharides (taro-4-I-polysaccharide, taro-polysaccharides 1 and 2 (TPS-1 / TPS-2)), lipids (monogalactosyldiacylglycerols (MGDGs), and digalactosyldiacylglycerol (DGDGs)), non-polyphenol antioxidants and A-1 / B-2 amylase inhibitors (Ramanatha *et al.,* 2010; Pereira *et al.,* 2021). Many of these bioactive principles have already been identified and examined individually, demonstrating their participation in these claimed activities.

Health Benefits of Consuming Cocoyam

Antioxidant Properties

Antioxidants, in appropriate concentrations, have the ability to protect, prevent or retard the oxidation of biomolecules such as nucleic acids (DNA and RNA), proteins and lipids (Halliwell and Gutteridge, 2015). Phytochemicals found in foods such as fruits, vegetables, grains, and tubers have antioxidant effects and are notable as relevant nutritional intervention programs. The assessment of the total antioxidant capacity (TAC) of foods is useful for improving functional, nutritional quality and maintaining health (Valtuena *et al.,* 2008; Sharifi-Rad *et al*., 2020). Many phytochemicals such as flavonoids, tannins, saponins, alkaloids, carotenoids, phenols, vitamins and fatty acids seem to contribute to the overall antioxidant capacity of taro (Simsek and El, 2015; Eleazu *et al.,* 2016; Eleazu *et al.*, 2013).

The H-ORAC (Hydroxyl Radical Antioxidant Capacity), ABTS (2.20 -azino-bis [3-ethylbenzothiazoline-6-sulfonic acid] diammonium salt), FRAP (iron reducing antioxidant power) and DPPH (2,20 -diphenyl - 1-Picrylhydrazyl radical assay) were used to assess the TAC of taro extracts or taro food derivatives (Pereira *et al.,* 2021). Research suggests different antioxidants in different amounts in taro and taro derivatives, and these differences could be attributed to several factors, such as (i) genetic background between variants of the same species; (ii) the agricultural cultivation methods used (iii) post-harvest processing, including handling, cutting, peeling, drying, cooking and storage; and (iv) non-standard bioactivity extraction methods (Goncalves *et al.,* 2013; Ferreres *et al.,* 2012; Chipurura *et al.,* 2010).

Few studies went beyond TAC determination and the characterization of phytochemical groups to identify specific compounds within the above class and in what concentrations they occur in taro (Agbor-Egbe and Rickard, 1990; Isabelle *et al.,* 2010; Chakraborty *et al.,* 2015). The taro matrix represents a complex set of antioxidants, and while they have been identified and measured, it is difficult to predict what role a single compound will play in the human body (Pereira *et al.,* 2021). Interestingly, taro antioxidants can work in combination to promote synergistic or antagonistic effects (Collins, 2005).

Bioactive compounds such as chlorogenic acid, catechin, epicatechin, epigallocatechin, proanthocyanidins and gallic acid have been identified in Taro by thin layer chromatography (TLC) and high performance liquid chromatography (HPLC) (Agbor-Egbe and Rickard, 1990). LC-MS (liquid chromatography-mass spectrometry) was also used to identify the polyphenols represented by 1-O-feruloyl-D-glucoside; 3,5-DiCQ acid; Vitexin; Isovitexin; Cyanidin-3-glucoside; Luteolin-7-O-rutinoside; Vicenin-2; Caffeic acid; Cyanidin-3-rhamnoside; Chlorogenic acid; Quercetin and hyperoxide (Kumar and Sharma, 2017).

Also, polyphenols and other antioxidants contained in taro, in addition to their function as normal radical scavengers, have other molecular and enzymatic mechanisms that are considered complementary for health promotion (Pereira *et al.,* 2021). Few mechanisms of action describe how polyphenols participate in inflammatory cascades by increasing the release of proinflammatory cytokines. As a result, inflammation can, for example, activate the transcription factor NF-B (nuclear factor kappa B) and stimulate the production of TNF-, two critical factors that, if upregulated, can be involved in the development of cancer (Pereira et al., 2021). Therefore, polyphenols could help control cancer progression due to their anti-inflammatory effects, including activating antioxidant enzymes, inhibiting prooxidative enzymes, and preventing free radical attacks (Belik *et al.,* 2013).

Anti-inflammatory effects

Taro extracts have also shown anti-inflammatory effects against human and mouse breast cancer cells by increasing the immune response by reducing the release of prostaglandin E2 (PGE2), accompanied by the abolition of the mRNA synthesis of cyclooxygenase-2 (COX-2) modulate and decrease in COX-1 (Kundu *et al.,* 2012). Tarin downregulation of the COX-2 gene lowered E-series prostaglandins by nearly 70%, particularly PGE2, an inflammatory mediator known to exert pro-tumorigenic effects, and contributes to (i) generating additional mutations in Cancer cells by stimulating the release of ROS; (ii) upregulation of a number of critical molecules such as Bcl-2 that confer resistance to apoptosis, vascular endothelial growth factor (VEGF) involved in angiogenesis, type 2 and 9 matrix metalloproteinases (MMPs) which are invasive, confer the ability to epidermal growth factor receptor (EGFR), which facilitates cell proliferation, extracellular signal-regulated kinase (ERK) and membrane proteases, which are also involved in the invasion; (iii) suppressing the anti-tumor response by downregulating the immune system; (iv) activation of the WNT / catenin pathway, which promotes metastasis and maintains stem cell capabilities; (v) Activation of the phosphatidylinositol-3-kinase / protein kinase B (PI3K / AKT) pathway, which promotes cell proliferation and survival (Pereira *et al.,* 2021). This would prevent the angiogenesis process, the proliferation, differentiation and migration of cancer cells (Kundu *et al.,* 2012; Liu *et al.,* 2015; Pannunzio and Coluccia, 2018; Hashemi *et al.,* 2019).

Anti-cancer Activities

Crude taro extract inhibits the *in vitro* proliferation of several human breast cancer lines, such as MCF-7, MDA-MB-231 and MCF10A, as well as the murine breast cancer lines 66.1, 410.4 and EpH4 (Pereira *et al.,* 2021). The antiproliferative effect on mouse cells was accompanied by morphological changes such as cell roundness and a reduction in the protrusion of the feet. Raw taro extract showed antimetastatic effects after intraperitoneal administration before and after the onset of cancer and exerted therapeutic and protective effects against the colonization of the heart and lungs by breast cancer lines (Kundu *et al.,* 2012). The anti-cancer effects promoted by taro extract were ascribed to a lectin (tarin) (PDB id. 5T1X and 5T20) (Pereira *et al.,* 2021). Lectin is able to reproduce the cancer-inhibiting and antimetastatic effects of the crude extract in in-vitro and in-vivo tests by inhibiting the proliferation of human hepatoma cells (HepG2 line) as well as lung and heart colonization (Kundu *et al*., 2012; Correa *et al.,* 2019).

Tarin, Nano-encapsulated in liposomes improved anticancer activity compared to the free protein against human breast cancer (MDA-MB-231) and glioblastoma (U87 MG) lines, which led to 41 and 65% inhibition, respectively (Pereira *et al*., 2021). Nano encapsulated tarin was as effective as cisplatin and temozolomide in controlling glioblastoma cell proliferation. However, the benefit stems from the non-cytotoxicity of either form of tarin, free or Nano encapsulated, at effective concentrations when added to healthy cells (Correa *et al.,* 2019). These results indicate that tarin has great potential as supportive cancer therapy (Yau *et al.,* 2010; Correa *et al.,* 2019). In addition, tarin is considered to be a relatively stable protein that maintains its activity over a wide range of pH and temperature, which are mandatory physicochemical properties for candidate molecules for pharmaceutical purposes (Pereira *et al.,* 2015).

Taro components have traditionally been known to enhance the immunological response, which could be an indirect way to reduce cancer risk or control tumorigenesis. Indeed, in mice, tarin has been shown to stimulate *in vitro* and *in vivo* proliferation of bone marrow (BM) and spleen cells while protecting BM progenitor cells from death. B lymphocytes and granulocytic cells were identified among the proliferating cells when taro extract was administered intraperitoneally (1 mg / animal) (Pereira *et al.,* 2021). In addition, tarin-sensitized splenocytes were stimulated to release IL-2, IL-1b, TNF and INF, which, as already mentioned, are essential cytokines involved in the cancer reaction (Chipurura *et al*., 2010; Rebey *et al.,* 2012; Asadi-Samani *et al.,* 2019; Wang and Higa, 1983).

Given that tarin is found in the edible part of *C. esculenta,* regular intake of this tubercle could be a useful dietary intervention to strengthen the immune system in healthy individuals or to speed recovery from leukopenia in immunocompromised patients, including those on chemotherapy (Pereira *et al.,* 2021). Tarin's immunomodulatory potential was demonstrated by administering the purified protein (200 g / animal) to cyclophosphamide immunosuppressed mice, where BM cells were stimulated to multiply and differentiate into a granulocytic cell line, promoting faster recovery from leukopenia (Pereira *et al.,* 2021). Tarin also protects the erythroid BM precursors from the cyclophosphamide cytotoxicity (Merida *et al.,* 2018).

The Effect of Cocoyam on Type II Diabetes and Obesity

Obesity or overweight is the main risk factor for developing Type II diabetes. Diabetes, obesity, hyperglycemia, and hypercholesterolemia, occurring together or independently, have been directly linked to cancers of the kidney, bladder, thyroid, ovaries, breast, endometrium, stomach, liver, pancreas, colon, and rectum and associated with leukemia (Pereira *et al.,* 2021). A recommended strategy for preventing overweight or obesity is adopting a healthier lifestyle (Garcia-Jimenez *et al.,* 2016; Tie *et al*., 2017; WHO, 2020). Taro can be a strong ally given its mean glycemic index, as 33% of total taro starch after cooking is made up of slow-digesting starch (SDS) and resistant starch (RS), and high fiber content, two essential properties it has to cope with these metabolic disorders.

Taro meal, offered to streptozotocin (STZ) -induced hyperglycemic rats, restored glycemia after four weeks of ingestion. Proteinuria and glucosuria, kidney function, relative kidney weights, liver function, glycated hemoglobin, and body obesity associated with type II diabetes were also attenuated after consuming taro. Plasma levels of total cholesterol, VLDL and LDL cholesterol, triacylglycerol, serum pancreatic lipase, atherogenic and coronary risk were all reset and HDL cholesterol levels were increased (Eleazu *et al.,* 2016; Eleazu *et al.,* 2013; Eleazu *et al.,* 2014). Similar effects were achieved by administering an ethanolic extract from raw taro flour, which reduced glucose tolerance and glycemia in a mouse model (Islam *et al.,* 2018). The antihyperglycemic and antihyperlipidemic effects observed herein indicate that taro may have the potential to treat diabetes and obesity. These effects are mainly attributed to bioactive compounds such as flavonoids, alkaloids, saponins, steroids and tannins, but minerals (Mg, Ca, K, P, Fe and Zn) and raw fiber also play a role (Eleazu *et al.,* 2013; Islam *et al*. 2018).

Food Uses of Cocoyam

In addition to the rich taste of most forms of cocoyam based foods, they are also valued for their nutritional and medicinal properties. The bulbs and tubers of taro and tannia can be cooked and crushed on sole or mixed with yam and plantain and eaten as fufu with soup (Adeyanju *et al.,* 2019). Tannia's tubers can be processed into various forms of food. They can be boiled, fried, baked, roasted, pounded into a paste or prepared as flour, chips, pepper soup or porridge (Ubalua, 2016). In Hawaii, taro is made into packaged food poi, a sour paste made from cooked crushed taro tubers (Brown and Valiere, 2004). The grain size is uniquely small, resulting in easy digestibility of starch, estimated at 98.8%. Although taro tubers are low in fat and protein; however, its protein is comparable to or slightly higher than that of yam, cassava and sweet potato (Deo *et al.*, 2009). Nutritionally, taros protein is rich in some essential amino acids but poor in isoleucine, tryptophan, and methionine (Onwueme, 1978). Cho *et al.* (2007) reported that a regular meal of taro tubers was a good source of calcium and iron.

Also in the food formulation context, taro and tannia compete favorably with other root and tuber crops and could be even further diversified if appropriate technologies are used to process them. Opara, (2003), described some recipes based on taro products. Technically, the unique small starch granules (1-4 m) of taros seem to be the reason why they are most commonly converted to more consumable forms such as flour, cereal products, poi, powdered drinks, chips, sun-dried slices, grits, and drum-dried flakes. The small starch grains (1-4 m) compared to the large grain size of Tannia (17-20 m) recommend taro as suitable for several foods, especially as food for potentially allergic infants and people with gastrointestinal diseases (Opara, 2003).

Tannia, is less easily digestible than taro, but richer in minerals with approximately the same protein content. Some special quality features of the aroid starch that are important for industrial use are particle size, dough temperature and amylose content (Opara, 2003). In comparison, several taro varieties have a particle size of 1-6.5 m in mean diameter, compared to rice starch at around 5 m, which is the finest of the starches commonly available (Griffin and Wang, 1983). Tannia starch, on the other hand, has relatively large grains with an average diameter of 17-20 m. Interestingly, since the dough temperature of starch is also important during processing and industrial application, the combination of aroid properties, particularly taros high dough temperatures and particle size, could offer a unique combination (Adeyanju *et al.,* 2019). Aroid starch could be used industrially for the production of syrups, cosmetics, gums, packaging films with a modified atmosphere, fillers / modifiers for plastics and renewable energies (Opara, 2003).

Taro is mainly used as a soup thickener. Such soups, when made with bitter leaves (*Veronia amygdalina*) or *ora* leaves, stock fish, dried fish, pepper, red palm oil, meat, crayfish, salt, fermented *ogiri* (*Ricinus communis)* and eaten with fufu are popular in Nigeria- a treat among the Igbos and Yorubas (Adeyanju *et al.,* 2019). Taro can also be kneaded and made into biscuits (*Achicha ede).* The processing of cocoyam (taro) to make *Achicha ede* begins with boiling the tubers for about 12 hours (usually overnight) until they have a brownish color. The outer skin is then removed and the pulp cut into slices and dried in the Harmattan wind (December to February) for about 4 to 5 days. The dried taro flakes are stored over the fireplace for 3-4 months until they are properly dried and chocolate-colored. When dried, they can be stored in clay pots for up to 6 months to provide nourishment during lean periods. They are cooked with beans (*Phaseolus spp.),* Cut fermented African oil beans (*Pentaclethra macrophylla),* spices and red palm oil, pepper and salt (Davidson *et al.,* 2019).

The leaves, petioles, runners, and inflorescence of cocoyam are delicacies and are an important source of vitamins, particularly folic acid, in some countries and communities (Martin *et al.,* 1998). Tannia leaves, especially the young succulents, are a delicacy among the Efiks of southern Nigeria. They are cooked with grated water yam or grated tubers of tannia, dried fish, periwinkles and various spices and eaten as a delicacy called *Ekpang Nkwukwo* (Aderanju *et al.,* 2019). Arene (1987) indicated that these leaves are rich in thiamine and that the thiamine provides a vital nutritional contribution to human nutrition. In Nigeria, tannia chips and flakes are also produced and consumed like the popular potato chips. Payne *et al.*, (1941) and Plucknet (1979) reported on the use of taros vitamins (A and B), Ca and phosphorus as a basis for industrial food preparations for babies. In addition, the easy digestibility of taros flour makes it suitable as a food for diabetics, potentially allergic infants and people with gastrointestinal diseases (FAO, 1990). Taro flour is also classified as superior to cassava, corn or potato starch in the production of polystyrene, polyethylene and polyvinyl plastics.

In addition, Plucknet *et al.* (1979) reported on its ability to reduce tooth decay in children. Similarly, Onwueme reported in 1978 that taro flour was effectively used in bakeries for baking and confectionery because of its pentosan content, while Griffin and Wang reported the importance of taro starch grain size in 1983, which makes it ideal for industrial use in the manufacture of face powders and cosmetics. In Hawaii, dehydrated cooked taro was used as the base for the production of powdered drinks, which is marketed under the name RA-RO-CO as a chocolate-flavored taro drink with added sugar, cocoa, milk and salt (Payne *et al*., 1941) . Other useful applications include use as a nourishing flavor ingredient in ice cream, in syrup and alcohol production, and as a filler for plastics and taro gums. Taro slime has also been reported to be useful in the pharmaceutical, plastic and paper industries (Gooding, 1987; FAO, 1990).

Conclusion

Many root and tuber crops are grown in hot and humid regions around the world for their use as vegetables because most of them contain starch as their main carbohydrate. They are an important part of human nutrition and provide variety. Cocoyam is one of the most important root and tuber plants grown for various purposes. Although neglected, it is a valuable source of several health-promoting bioactive compounds, such as taro lectin or tarin, bioactive-complex carbohydrates, and natural polyphenols and other antioxidants. In general, these molecules act through individual or synergistic pathways and provide numerous health benefits to their consumers, such as anti-cancer, anti-inflammatory, antioxidant and dyslipemic activities. Interestingly, Cocoyam can be made into more stable foods so that shelf life can be extended and processed into more consumable forms. These include poi (fresh or fermented paste), cocoa flour, grain base, chips, sun-dried slices, grits, baby weaning foods, and drum-dried flakes. Consumers of cocoyam-based products can rest assured that they are getting these numerous health benefits associated with cocoyam.

References

Agbor-Egbe, T. a& Rickard, J. E. (1990). Identification of phenolic compounds in edible aroids. *Journal of the Science of Food and Agriculture,* 215–221.

Agrid, M. C. (2006). Minerals: Dietary need absorption, transport and excretion. Workshop Seminar, pp. 21-24.

Ahmed, A. & Khan, F. (2013). Extraction of Starch from Taro (*Colocasia esculenta*) and Evaluating it and further using Taro Starch as Disintegrating Agent in Tablet Formulation with Over All Evaluation. *Inventi Rapid: Novel Excipients*, *2*, 1–5.

Ahmed, I., Lockhart, P. J., Agoo, E. M., Naing, K. W., Nguyen, D. V., Medhi, D. K. & Matthews, P. J. (2020). Evolutionary origin of taro (*Colocasia esculenta*) in Southeast Asia. *Ecology and Evolution,* 10, 1–14.

Akshatha, M., Kavadikeri, S. & Rao, N. N. (2018). In vitro micropropagation and antioxidant assay in *Colocasia esculenta.* Plant Tissue *Culture and Biotechnology,* 28, 183–190.

Akyuz, M. (2019). Determination of Antioxidant Activity of Ethanol Extract of Gölevez *[(Colocasia esculenta (L.)]* Tubers. *Ksu Journal of Agriculture and Nature*, 22, 388–394.

Alcantara, M., Hurtada, A. & Dizon, I. (2013). The nutritional value and phytochemical components of taro [*Colocasia esculenta* (L.) Schott] powder and its selected processed foods. *Nutrition and Food Science*, 3, 3.

Amin, I. & Lee, W. Y. (2005). Effect of different blanching times on antioxidant properties in selected cruciferous vegetables. *Journal of the Science of Food and Agriculture,* 85, 2314–2320.

Arene, O. B. (1987). Allochemicals in Aroids: Sequence of a proteinase inhibitor from *Allocasia macrorrhiza*. Ph.D Thesis, Australian National University, Canberra, Australia.

Asadi-Samani, M., Farkhad, N. K., Mahmoudian-Sani, M. R. & Shirzad, H. (2019). Antioxidants as a Double-Edged Sword in the Treatment of Cancer. IntechOpen,London, UK.

Awa, E. & Eleazu, C. (2015). Bioactive constituents and antioxidant activities of raw and processed cocoyam (*Colocasia esculenta). Nutrafoods*, 14, 133–140.

Bae, H., Jayaprakasha, G. K., Crosby, K., Jifon, J. L. & Patil, B. S. (2012). Influence of extraction solvents on antioxidant activity and the content of bioactive compounds in non-pungent peppers. *Plant Foods for Human Nutrition,* 67, 120–128.

Bellik, Y., Boukraâ, L., Alzahrani, H. A., Bakhotmah, B. A., Abdellah, F., Hammoudi, S. M. & Iguer-Ouada, M. (2013). Molecular mechanism underlying anti-inflammatory and anti-allergic activities of phytochemicals: An update. *Molecules*, 18, 322.

Bhagyashree, R. P. & Hussein, M. A. (2011). Antihepatotoxic effect of *Colocasia esculenta* leaf juice. *International Journal of Advanced Biotechnology Research*, *2*, 296–304.

Biziuk, M. & Kuczynska, J. (2006). Mineral Components in Food-Analytical Implication. In *Mineral Components in Foods*; Chemical and Functional Properties of Food Components Series; CRC Press: Boca Raton, FL, USA, pp. 1–31.

Bradbury, J. H. & Holloway, W. D. (1988). Chemistry of Tropical Root Crops. Significance for Nutrition and Agriculture in the Pacific. Australian Centre for International Agricultural

Research, Canberra, Australia, pp. 51-68, 110-19.
Brown, A. C., & Valerie, M. S. (2004). The medicinal uses of poi. *Nutrition in clinical care,* 7(2): 69-74.
Ceccarelli, S. (2009). Evolution, plant breeding and biodiversity. *Journal of Agriculture and Environment for International Development*, 103 (1/2): 131- 145.
Chakraborty, P., Deb, P., Chakraborty, S., Chatterjee, B. & Abraham, J. (2015). Cytotoxicity and antimicrobial activity of *Colocasia esculenta*. *Journal of Chemical and Pharmaceutical Research*, 7, 627–635.
Chipurura, B., Muchuweti, M. and Manditseraa, F. (2010). Effects of thermal treatment on the phenolic content and antioxidant activity of some vegetables. *Asian J. Clin. Nutr*, 2, 93–100.
Cho J., Yamakawa, R. & Hollyer, J. (2007). Hawaiian kalo, past and future. *Sustain Agric.* 001.8p. http://www.ctahr.hawaii.edu/oc/freepubs/pdf/SA-1.
Collins, A. R. (2005). Antioxidant intervention as a route to cancer prevention. *Eur. J. Cancer*, 41, 1923–1930.
Corrêa, A. C. N. T. F., Vericimo, M. A., Dashevskiy, A., Pereira, P. R. & Paschoalin, V. M. F. (2019). Liposomal Taro Lectin Nanocapsules Control Human Glioblastoma and Mammary Adenocarcinoma Cell Proliferation. *Molecules*, 24, 471.
de Castro, L. A. B., Carniero, M., MonteNechish, D. C. & de Paiva, G. R. (1992). Spatial and temporal gene expression patterns occur during corm development. *Plant Cell*, 4, 1549-1559.
Deo, P. C., Tyagi, A. P., Taylor, M., Becker, D. K. and Harding, R. M. (2009). Improving taro (*Colocasia esculenta* var. *esculenta*) production using biotechnological approaches. *South Pacific J Nat Sci.* 27: 6-13.
El-Dardiry, A. I., Ewis, A. M. & Abo-Srea, M. (2018). Impact of Taro Corms on Functional Low Fat Ice Cream Properties. *J. Food Dairy Sci*, 9, 399–402.
Eleazu, C. O. (2016). Characterization of the natural products in cocoyam (*Colocasia esculenta*) using GC–MS. Pharm. Biol. 2016, 54, 2880–2885.
Eleazu, C. O., Iroaganachi, M. A. and Eleazu, K. C. (2013). Ameliorative potentials of cocoyam (*Colocasia esculenta* L.) & unripe plantain (*Musa paradisiaca* L.) on the relative tissue weights of streptozotocin-induced diabetic rats. *J. Diabetes Res.* 2013, 160964.
Eleazu, C. O., Okafor, P. N. & Ifeoma, I. (2014). Biochemical basis of the use of cocoyam (*Colocasia esculenta* L.) in the dietary management of diabetes and its complications in streptozotocin induced diabetes in rats. *Asian Pac. J. Trop. Dis.* 4, S705–S711.
FAO (1990). Roots, tubers, plantains and bananas in nutrition. FAO, Rome, Italy.
FAO (1999). *Growing Taro in Asia and the Pacific*; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, Available online:http://ebooks.lib.ntu.edu.tw/1_file/FAO/67652/ac450e00.pdf(accessed on 15 February 2021).
FAO (2008). Importance of Taro. Available online:http:www.fao.org/docrep/005/AC450e(accessed on 15 February 2021).
FAO (2004). Protein Sources for the Animal Feed Industry. (Animal Production and Health); Expert Consultation and Workshop: Bangkok, Thailand.
Ferreres, F., Goncalves, R. F., Gil-Izquierdo, A., Valentao, P., Silva, A. M., Silva, J. B., Santos, D. and Andrade, P. B. (2012). Further knowledge on the phenolic profile of *Colocasia esculenta* (L.) Shott. *J. Agric. Food Chem.* 60, 7005–7015.
Wada, E., Feyissa, T. & Tesfaye, K. (2019). Proximate, mineral and antinutrient contents of cocoyam (*Xanthosoma sagittifolium* (L.) Schott) from Ethiopia. *International journal of Food science*, 3, 1-8. DOI: 10.1155/2019/8965476.
García-Jiménez, C., Gutiérrez-Salmerón, M., Chocarro-Calvo, A., García-Martinez, J. M., Castaño, A. & De la Vieja, A. (2016). From obesity to diabetes and cancer: Epidemiological links and role of therapies. *Br. J. Cancer*, 114, 716–722.
Goncalves, R. F., Silva, A. M., Silva, A. M., Valentao, P., Ferreres, F., Gil-Izquierdo, A., Silva, J. B., Santos, D. & Andrade, P. B. (2013). Influence of taro (*Colocasia esculenta* L. Shott) growth conditions on the phenolic composition and biological properties. *Food Chem.* 141, 3480–3485.
Gooding, E. G. B. (1987). Root crops. TDRI, London, pp. 223- 233.
Griffin, G. J. L. & Wang, J. (1983). Industrial uses. In: Wang, P. (Ed) Taro: a review of *Colocasia*

esculenta and its potentials . Univ. of Hawaii press. Honolulu 400 pp.

Hahn, S. K. (1984). Tropical root crops, their improvement and utilization. Paper presented at the conference organized by the Common Wealth Agric. Bureau on Advancing agricultural production in Africa, Arusha, Tanzania International Conference. (IITA), p 2, 28.

Halliwell, B. & Gutteridge, J. M. (2015). Free Radicals in Biology and Medicine; Oxford University Press: New York, NY, USA.

Igwe, C.U., Donatus, D.L.A., Obiora, N.G., Ikaraoha, I. & Hughs, M.A.T. (2004). Effects of Colocasia esculenta (taro cocoyam) based diets on hepatic cholesterol and phospholipid levels in albino rats. *Emirates medical journal*, 22(2): 123-126.

Isabelle, M., Lee, B. L., Lim, M. T., Koh, W. P., Huang, D. & Ong, C. N. (2010). Antioxidant activity and profiles of common fruits in Singapore. *Food Chem*. 123, 77–84.

Islam, M. H., Mostafa, M. N. & Rahmatullah, M. (2018). Antihyperglycemic activity of methanolic extracts of corms of *Colocasia esculenta* var *esculenta. Eur. J. Pharm. Med. Res.* 5, 129–132.

Iwe, O. M. (2002) Handbook of sensory methods and analysis. Rojoint Com Services Ltd., Enugu, Nigeria.

Iwuagwu, M. O., Okpara, D. A. & Muoneke, C. O. (2017). Growth and yield responses of cocoyam (Colocasia esculenta (L.) Schott) to organic wastes in the humid Agro-Ecological Zone of South-eastern Nigeria. International journal of plant and soil science. 16(6): 1-11. ISSN: 2320-7035.

Kim, Y. S., Adeyemi, D., Korovulavula, P., Jang, D. W. & Park, M. K. (2019). Effect of steaming on the functional compounds and antioxidant activity of Fijian taro (*Colocasia esculenta* L. Schott) corms. *Korean J. Food Preserv.*, 26, 449–454.

Kumar, V. & Sharma, H. (2017). Process optimization for extraction of bioactive compounds from taro (*Colocasia esculenta*), using RSM and ANFIS modelling. *J. Food Meas. Charact.*, 11, 704–718.

Kundu, N., Campbell, P., Hampton, B., Lin, C.Y., Ma, X., Ambulos, N., Zhao, X. F., Goloubeva, O., Holt, D. & Fulton, A. M. (2012). Antimetastatic activity isolated from *Colocasia esculenta* (taro). *Anti-Cancer Drugs*, 23, 200.

Lebot, V. & Lawac, F. (2017). Quantitative comparison of individual sugars in cultivars and hybrids of taro [*Colocasia esculenta* (L.) Schott]: Implications for breeding programs. *Euphytica*, *213*, 147.

Lebot, V. & Legendre, L. (2015). HPTLC screening of taro hybrids (*Colocasia esculenta* (L.) Schott) with high flavonoids and antioxidants contents. *Plant Breed.*, *134*, 129–134.

Lebot, V., Malapa, R. & Bourrieau, M. (2011). Rapid estimation of taro (*Colocasia esculenta*) quality by near-infrared reflectance spectroscopy. *J. Agric. Food Chem.*, *14*, 9327–9334.

Lebot, V., Prana, M. S., Kreike, N., van Eck, H. J., Pardales, J., Okpul, T., Gunua, T., Thongjiem, T. M., Hue, H. & Viet, N. (2004). Characterization of the genetic resources of taro (*Colocasia esculenta* (L.) Schott) in Southeast Asia and Oceania. *Genet. Resour. Crop Evol.*, *51*, 381–392.

Lee, S., Wee, W., Yong, J. & Syamsumir, D. (2011). Antimicrobial, antioxidant, anticancer property and chemical composition of different parts (corm, stem and leave) of *Colocasia esculenta* extract. *Ann. Univ. Mariae Curie-Skłodowska*, 24, 9–16.

Lewu, M. N., Adebola, P. O. & Afolayan, A. J. (2010). Effect of cooking on mineral content and anti-nutritional factors in seven accessions of *Colocasia esculenta* (L.) Schott growing in South Africa Composition. *J. Food Compos. Anal.*, *23*, 389–393.

Lindsey, K., Motsei, M. & Jäger, A. (2002). Screening of South African food plants for antioxidant activity. *J. Food Sci.*, 67, 2129–2131.

Liu, B., Qu, L. & Yan, S. (2015). Cyclooxygenase-2 promotes tumour growth and suppresses tumour immunity. *Cancer Cell Int.*, 15, 106.

Lucy, M., Reed, E. & Glick, B. R. (2004). Use of free growth in living plants-promoting rhizobacteria. *Antonie Leeuwenhoek*, *86*, 102.

Martin, F. W., Ruberte, R. M., & Meitzner, L. S. (1998). Edible leaves of the tropics, Publisher, Echo. USA.

Mergedus, A., Kristl, J., Ivancic, A., Sober, A., Sustar, V., Krizan, T. & Lebot, V. (2015). Variation of mineral composition in different parts of taro (*Colocasia esculenta*) corms. *Food Chem.*, *170*, 37–46.

Merida, L. A., Mattos, E. B., Correa, A. C., Pereira, P. R., Paschoalin, V. M., Pinho, M. F. &

Vericimo, M. A. (2018). Tarin stimulates granulocyte growth in bone marrow cell cultures and minimizes immunosuppression by cyclo-phosphamide in mice. *PLoS ONE*, 13, e0206240.
Monte Neschich, D. C., Rocha, T. L., Guimaraes, R. C., Santana, E. F., Loureiro, M. E., Valle, M. & de Sa, M. F. G. (1995). Characterization and spatial localization of the major globulin families of taro (*Colocasia esculenta* L. Schott) tuber. *International Journal of Plant Sciences,* 112, 149-159.
Nip, W. K. (1997). Taro root. In *Taro: Vegetable Processing and Technology*; Technomic Publishing: Pennsylvania, PA, USA, pp. 355–387.
Nip, W. K., Muchille, J., Cai, T. & Moy, J. H. (1989). Nutritive and non-nutrient in taro (*Colocasia esculenta* (L.) Schott) from American Samoa. *J. Hawaii Pac. Agric., 2,* 1–5.
Njintang, Y., Mbofung, F., Balaam, F., Kitissou, P. & Scher, J. (2008). Effect of taro (*Colocasia esculenta* (L.) Schott) addition of functional flour and alveographic properties of flour and wheat dough. *J. Agric. Food Sci*., *88*, 273–279.
Obioha, F. C. (1972). Utilization of cassava as human feed. A literature review and research recommendation on cassava A.I.D. csd/2497. Univ. of Georgia, pp 325, 1972.
Ojimelukwe, P., Ukom, A.N., Ezeama, C., Oritz, D.O. & Aragon, I.J. (2014). Phenolic content and antioxidant activity of some under-utilized Nigerian yam (Dioscorea spp.) and cocoyam (Xanthosoma maffa (scoth) tubers. *IOSR Journal of Environmental Science, Toxicology and Food Technology,* 8(7): 104-111. DOI: 10.9790/2402-0871104111.
Onwueme, I. (1999). Taro cultivation in Asia and the Pacific. Food and agriculture organization of the United Nations regional office for Asia and the Pacific Bangkok, Thailand.
Onwueme, I. C. (1978). The tropical tubers crops, yam, cassava, sweet potato, and cocoyam. John Wiley and sons, New York and Brisbane Toronto, pp.199-227.
Opara, E. U. & Nwankwo, I. M. (2015). The potentials of phytochemicals of some medicinal plants in control of Erwinia carotovora, the causative agent of soft rot disease of cocoyam. Journal of Microbiology Research and Reviews. Vol 3(2):17-23.
Opara, L. U. (2000). Edible aroids. Post-harvest operation, Massey university (FAO), New Zealand, Palmerston north. Electronic document: http://www.fao.org/fileadmin/ user upload/inpho/docs/Post_Harvestompendium_Edible_aroids.pdf.
Owusu-Darko, P. G. (2014). Tannia (Xanthosoma saggitifolium) starch: Properties and flavour volatiles release. *Journal of Agricultural Chemistry and Environment*, 3, 22-29.
Pannunzio, A. and Coluccia, M. (2018). Cyclooxygenase-1 (COX-1) and COX-1 inhibitors in cancer: A review of oncology and medicinal chemistry literature. *Pharmaceuticals*, 11, 101.
Payne, J. H., Ley, G. J. & Akau, G. (1941). Processing and chemical investigations of taro. Bulletin 086. 42p.
Pereira, P. R., Winter, H.C., Verícimo, M. A., Meagher, J. L., Stuckey, J. A., Goldstein, I. J., Paschoalin, V. M. F. and Silva, J. T. (2015). Structural analysis and binding properties of isoforms of tarin, the GNA-related lectin from *Colocasia esculenta*. *Biochim. Biophys. Acta (BBA)-Proteins Proteom*., 1854, 20–30.
Plucknet, D. L. (1979). Colocasia, Xanthosoma, Alocasia, Crytosperma and Amorphophallus, pp.127-135. In: tropical root and tuber crops tomorrow, vol., 1: Proceedings of the second international symposium on tropical root and tuber crops. Edited by D. L. Plucknett. College of tropical agriculture, university of Hawaii, Honolulu.
Ramat, A. I. (2014). Cocoyam: an ideal food for prevention. www.theheraldnews.info.
Rebey, I. B., Bourgou, S., Debez, I. B. S., Karoui, I. J., Sellami, I. H., Msaada, K., Limam, F. & Marzouk, B. (2012). Effects of extraction solvents and provenances on phenolic contents and antioxidant activities of cumin (Cuminum cyminum L.) seeds. *Food Bioprocess Technol.,* 5, 2827–2836.
Sanful, R.E. & Darko, S. (2010). Production of cocoyam, cassava and wheat flour composite rock cake. *Pakistan journal of nutrition*, 9(8): 810-814. ISSN 1680-5194.
Sefa-Dede, S. & Agyir-Sackey, E. K. (2004). Chemical composition and the effect of processing on oxalate content of cocoyam (*Xanthosoma sagittifolium*) and (*Colocasia esculenta*) cormels, *Food Chemistry*, 85, (4) 479–487.
Sharifi-Rad, M., Anil Kumar, N.V., Zucca, P., Varoni, E. M., Dini, L., Panzarini, E., Rajkovic, J., Tsouh Fokou, P.V., Azzini, E. & Peluso, I. (2020). Lifestyle, Oxidative Stress, and

Antioxidants: Back and Forth in the Pathophysiology of Chronic Diseases. *Front. Physiol.*, 11, 694.

Sharma, V., Paliwal, D. R., Jammeda, P. & Sharma, S. (2012). Chemo preventive efficacy of *Moringa oleifera* pods against 7, 12-dimethylbenz[a]anthracene induced hepatic carcinogenesis in mice. *Asian Pacific Journal of Cancer Prev*. 13(6):2563-2569.

Sharma, S., Jan, R., Kaur, R. & Riar, C. S. (2020). Taro (*Colocasia esculenta*). In *Antioxidants in Vegetables and Nuts—Properties and Health Benefits*; Nayik, G.A., Gull, A., Eds.; Springer: Singapore.

Simsek, S. & El, S. N. (2015). *In vitro* starch digestibility, estimated glycaemic index and antioxidant potential of taro (*Colocasia esculenta* L. Schott) corm. *Food Chem.*, 168, 257–261.

Takebayashi, J., Oki, T., Watanabe, J., Yamasaki, K., Chen, J., Sato-Furukawa, M., Tsubota-Utsugi, M., Taku, K. & Goto, K. (2013). Matsumoto, T. Hydrophilic antioxidant capacities of vegetables and fruits commonly consumed in Japan and estimated average daily intake of hydrophilic antioxidants from these foods. *J. Food Compos. Anal.*, 29, 25–31.

Temesgen, M. & M. Ratta (2015). Nutritional Potential and Food Safety Benefits of Taro *Colocasia esculenta* (L.): A review. *Food Science and Quality Management*, 36, 23-31.

Tie, G., Yan, J., Khair, L., Messina, J. A., Deng, A., Kang, J., Fazzio, T., & Messina, L. M. (2017). Hypercholesterolemia Increases Colorectal Cancer Incidence by Reducing Production of NKT and γδ T Cells from Hematopoietic Stem Cells. *Cancer Res.*, 77, 2351.

Tuti, M., Pal, R., Arun Kumar, R., Bist, J. & Bhatt, J. (2015). *Colocasia* based cropping systems affects the antioxidant properties and productivity of *colocasia* [*Colocasia esculenta* (l.) schott] tuber. *Bioscan Int. Q. J. Life Sci.*, 10, 117–123.

Ubalua, A. O. (2016). Cocoyam (taro and tannia): Staples with untapped enormous potentials-A Review. *Plant knowledge journal. 5*(1): 27-35 | DOI: 10.21475/pkj.05.01.16.p7058.

Valtuena, S., Pellegrini, N., Franzini, L., Bianchi, M. A., Ardigo, D., Del Rio, D., Piatti, P., Scazzina, F., Zavaroni, I. & Brighenti, F. (2008). Food selection based on total antioxidant capacity can modify antioxidant intake, systemic inflammation, and liver function without altering markers of oxidative stress. *Am. J. Clin. Nutr.*, 87, 1290–1297.

Wang, J. K. & Higa, S. (1983). Taro, a Review of *Colocasia Esculenta* and Its Potentials; University of Hawaii Press: Honolulu, HI, USA.

WHO. Obesity. Available online: https://www.who.int/health-topics/obesity#tab=tab_1 (accessed on 30 September 2021).

Yau Sang, C., Jack Ho, W. & Tzi Bun, N. A. (2010). Cytokine-Inducing Hemagglutinin from Small Taros. *Protein Pept. Lett.*,17, 823–830.